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services qualify for a permanent grant of spectrum in the 902-928 MHz band. Because various LMS services use spectrum in different ways, it is necessary to distinguish among LMS services in determining whether statutory standards such as spectrum efficiency are satisfied. Although certain LMS services qualify for permanent allocation of spectrum, other services permitted by the proposed rules do not meet statutory requirements for spectrum efficiency and other criteria and should not be granted authorization. Accordingly, modification of the rules proposed in the NPRM is needed so that they cover only those services that meet the statutory requirements.

Specifically, wideband pulse-ranging systems, such as the Teletrac[2] vehicle location system, do not meet the statutory standards for: improving spectrum efficiency; increasing sharing between different types of users; fostering competition; and serving the largest number of users.[3] These systems use much more spectrum than is necessary for the intended purpose. They require that the vehicle to be located transmit a wideband pulse (up to 8 MHz) over a wide area to several receiver sites. The location is determined by calculating the difference in the

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[2] North American Teletrac and Location Technologies, Inc. ("Teletrac"). The NPRM was issued by the Commission in response to a Petition for Rulemaking filed by Teletrac.

[3] Communications Act § 332, 47 U.S.C. § 332.

time of arrival of the pulse at the various sites, which necessitates a wideband signal for accuracy. Newer methods, however, can locate a vehicle with much less than the 8 MHz of spectrum allowed by the rules or the 4 MHz used by the Teletrac system.[4] For example, in an automatic vehicle location system based on Global Positioning System ("GPS") technology, the vehicle determines its own position coordinates using a GPS receiver, and relays that information to the base station via a narrowband mobile radio link authorized in a different frequency band.

The GPS system actually in place in Dallas uses three radio channels for the location function, with a total bandwidth of 75 KHz of spectrum. In contrast, the Teletrac system needs 4 MHz or over 50 times more spectrum than used in the Dallas system.

Another way of measuring spectrum efficiency of pulse-ranging and GPS location systems is the number of vehicles that can be located using a given amount of spectrum. Teletrac's 4 MHz system can handle 4,000 location requests per minute[5] using 4 MHz of spectrum. The Dallas GPS-based system locates 635 vehicles per minute using only 75 KHz.[6] Thus, the Teletrac system uses over 50 times more

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[4] Teletrac's Response to Comments of the Missile Group Old Crows, p. 12.

[5] Teletrac's Petition for Rulemaking, p. 7.

[6] See Paul Ledwitz, DART AVL Hits Transit Bulls-Eye with GPS, GPS World, Apr. 1993 at 33. The information on the

(footnote continued on following page)

spectrum than the spectrum used in the Dallas system to locate about six times the number of vehicles. Moreover, the GPS technology allows several competing systems to operate in the same area, while exclusive licensing is required for the Teletrac pulse-ranging system, as discussed below.

The wideband pulse-ranging systems also fail the statutory test of increasing the opportunity for sharing spectrum with other services.[7] For example, the Commission recognized that interference from Government services and ISM users will increase as LMS systems become more prevalent (NPRM, ¶ 23). The Commission also asked LMS providers to comment on measures that should be taken to achieve reliability from interference in the presence of Part 15 devices and amateur operations (NPRM, ¶ 24). The evidence in Teletrac's Petition for Rulemaking (Appendix 2), showing that there are no practical techniques to eliminate the effects of interference from other LMS systems (pp. 17-20), also establishes that interference from other sources cannot

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(footnote continued from previous page)

total spectrum used in the Dallas system was provided to AT&T by DART.

[7] The 902-928 MHz band is used by various Government services, Industrial, Scientific and Medical ("ISM") devices, amateur operators and Part 15 devices (spread spectrum devices pursuant to 47 C.F.R. § 15.247 and other devices pursuant to 47 C.F.R. § 15.249).

be avoided. Appendix A to these Comments contains an analysis by AT&T, based on the data in Teletrac's Appendix 2, demonstrating that wideband pulse-ranging systems[8] cannot operate reliably in the presence of interference from even a moderate number of Part 15 devices operating at fairly low power (e.g., 10 to 100 mWatts); higher powered transmitters of other services would create an even more serious problem.

In addition, pulse-ranging systems do not meet the statutory criterion of encouraging competition. The Commission would attempt to promote competition by means of non-exclusive licenses to LMS providers (NPRM, ¶ 21). However, Teletrac and others claim that exclusive licensing is required for effective operation (id), because LMS systems interfere with each other. AT&T's analysis of the data in Teletrac's Appendix 2 supports Teletrac's position on this point. On the other hand, multiple vendors of location services based on GPS technology should be able to compete for business in each area. Spectral inefficiency and the absence of competition show that pulse-ranging systems do not meet the statutory requirement of increasing the number of possible users of the band.

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[8] Teletrac states that the results it presents are "broadly applicable" to any system using time-of-arrival multilateration techniques with mobile transmitters (Appendix 2, p. 5).

Although pulse-ranging systems should not be allocated spectrum in the 902-928 MHz band, a viable alternative exists - GPS-based systems - to serve the vehicle location function without the deficiencies inherent in Teletrac-type systems. Others are presently using GPS technology to locate vehicles,[9] despite Teletrac's claim that there are obstacles to such use.[10] Also, a substantial portion of the control and monitoring capabilities of present pulse-ranging systems could be converted for use with GPS technology for vehicle location services.

In contrast to the Teletrac system, there are systems which are inherently highly spectrally efficient because they use spectrum only over a very small geographic area, typically distances of only about 10 meters or less between receiver and transmitter. This characteristic permits reuse of the spectrum many times over in other places in the community, whether the systems use a narrowband or wideband signal. One example is the narrowband system described in the NPRM for determining when vehicles pass certain fixed locations (¶ 11). Radio signals

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[9] See the citation in note 6 for a description of the Dallas system. Other systems are described in Glen Gibbons et al., Automatic Vehicle Location: GPS Meets IVHS, GPS World, Apr. 1993, at 23.

[10] Teletrac's Response to Comments of the Missile Group Old Crows, pp. 8-9.

are transmitted between the vehicle and a nearby station. Another example is the wideband system for electronic toll collection offered by AT&T. Readers in the toll plaza communicate with devices in the vehicle, exchanging information regarding where the vehicle entered and left the toll road and encrypted information needed to pay the toll and keep current the driver's account with the highway authority, as well as information useful for traffic management.

These small geographic area systems also meet the statutory standard of allowing sharing with other services. A major reason for interference is where the interfering transmitter is closer to the receiver than the desired transmitter. Because the transmitter and receiver in these systems are only a few meters apart, it is not likely that an interfering transmitter would be sufficiently close to the receiver to cause interference. The facts that the spectrum can be reused many times elsewhere in the community and that these users do not interfere with each other will permit extensive competition and maximize the number of users that may be served.

In sum, LMS services operating in a small geographic area meet the statutory tests and should be granted permanent authorization. The most effective way to limit the systems authorized in the rules to those that operate in relatively small geographic areas is to limit the output power and the height of the antenna structure. AT&T

recommends that a 30 Watt power limit and a 10 meter height limit be established in the rules.[11] This would permit efficient use of spectrum by multiple providers and protect short-range, low-power systems from interference.

Finally, the proposal in the NPRM to expand operation into the two 1 MHz edges (902-903 and 927-928 MHz) and the six MHz center (912-918 MHz) of the band, which presently are excluded, should not be adopted. Because those excluded frequencies are presently allocated on a primary basis for Federal Government use, assignment to LMS

APPENDIX A

AT&T Bell Laboratories

The discussion of co-channel interference on the return link (vehicle to base station) in Appendix 2 of Teletrac's Petition for Rulemaking which underlies the NPRM shows that wideband pulse-ranging LMS systems cannot share the same spectrum with spread spectrum frequency hopping Part 15 devices.[1] While that discussion was directed to the presence of other AVM systems, the results presented can be used to infer the impact of even a moderate number of Part 15 devices operating at fairly low power (e.g., 10 to 100 mWatts).

Teletrac's Appendix 2 presents the example of four receive sites on the corners of a square 10 miles on a side, with a vehicle in the center of the square (i.e., 7.1 miles from each site) and an interference source 7,000 feet from one of the receive sites (Teletrac's Figure 4), which makes that source roughly 10.1, 11.3 and 15.1 miles from the other three sites. The vehicle is assumed to transmit five Watts (the actual power of the Teletrac mobile transmitters) with an effective antenna gain of -6 dBi so that the effective power transmitted by the vehicle on the return link is 1.25 Watts. Teletrac's Figure 6 shows the position error produced by various transmit power

levels of the interfering source. That Figure shows that a transmit power of 10 Watts produces nearly a mile of position error, which must certainly be judged unacceptable by any standard. Given the 10 Watt transmit power of the interfering source, the C/I (carrier-to-interference ratio) at all four receive sites that results in this position error may be calculated:[2] -38 dB at the near tower and -2.8 dB, -0.8 dB and 4.2 dB at the other three. The only reasonable conclusion from these data is that the near tower contributes nothing to the determination of location and the time of arrival information at the other three is sufficiently corrupted so that an accurate determination of position cannot be made.[3]

These results show that the Teletrac system is extremely vulnerable to interference, even from devices that radiate relatively low power levels. For example, a transmitter radiating 10 mWatts one mile from an LMS base station would result in a C/I of -13 dB for a vehicle 7.1 miles away, meaning that the time of arrival data at that station will be too corrupted for it to contribute to locating the vehicle. Because

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[2] Using the fourth power law path loss assumed by Teletrac (p. 14 and n.7) and ignoring shadow fading and multipath effects in the interests of simplicity. Considering those

Part 15 devices can be expected to be operating at 10 mWatts or more, and often much closer than one mile to each of the base stations, LMS systems of the type operated by Teletrac will be unable to offer reliable service. Clearly the interference problem is even more severe with high power radiators such as amateur radio transmitters and ISM devices. Potential new services that could appropriately be authorized in the 902-928 MHz band would likely also disrupt the operation of a Teletrac-type system.

APPENDIX B

The material set forth below identifies each section of the rules proposed in the NPRM which should be adopted with no change and contains the text of rules that should be adopted other than as so proposed.

PART 2 - FREQUENCY ALLOCATIONS AND RADIO TREATY MATTERS; GENERAL RULES AND REGULATIONS

Authority citation for Part 2

No change.

§ 2.106

Section 2.106 is amended by adding "Private Land Mobile (90)" to the FCC use designators in the row for 902-928 MHz in the table and by revising footnotes US218 and US275 to read as follows:

* * * * *

International table	United States table		FCC use designators	
* * *	Government	Non-Government	Rule part(s)	Special-use frequencies
	* * * * *			
* * *	902-928 RADIOLOCATION		Private Land Mobile (90) Amateur (97)	902-928 915 ± 13 MHz Industrial scientific and medical frequency.
	707 US215 US218 US267 US275 G11 G59	707 US215 US218 US267 US275		

* * * * *

US218 The band segments 902-912 MHz and 918-928 MHz are available for Location and Monitoring Service (LMS) systems subject to not causing harmful interference to the operation of all Government stations authorized in these bands. These systems must tolerate interference from the operation of Industrial, scientific, and medical (ISM) devices and the operation of Government stations authorized in these bands.

US275 The band 902-928 MHz is allocated on a secondary basis to the amateur service subject to not causing harmful interference to the operations of Government stations authorized in this band or to Location and Monitoring Service (LMS) systems. Stations in the Amateur service must tolerate any interference from the operations of industrial, scientific, and medical (ISM) devices, LMS systems and the operations of Government stations authorized in this band. Further, the Amateur Service is prohibited in those portions of Texas and New Mexico bounded on the south by latitude 31°41' North, on the east by longitude 104°11' West, and on the north by latitude 34°30' North, and on the west by longitude 107°30' West; in addition, outside this area but within 150 miles of these boundaries of White Sands Missile Range the service is restricted to a maximum

PART 90 - PRIVATE LAND MOBILE RADIO SERVICES

Authority citation for Part 90

No change.

§ 90.7

Section 90.7 is amended by removing the entry for *Automatic Vehicle Monitoring* and adding a new definition for *Location and Monitoring Service* to read as follows:

Location and Monitoring Service (LMS). The use of non-voice signaling methods from and to vehicles and other objects to make known the location of such units. LMS systems may also transmit status and instructional messages related to the units involved.

§ 90.101

No change

§ 90.103

Section 90.103 is amended by adding 902-928 MHz to the Table in paragraph (b), by adding new paragraph (c)(31), by removing paragraph (d) and by redesignating existing paragraph (e) as paragraph (d) to read as follows:

* * * * *

(b) * * *

Radiolocation Service Frequency Table

Frequency or band	Class of Station	Limitation
* * * * *		
Megahertz:		
* * *		
902 to 928	do	31
* * * * *		

(c) * * *

(31) The 902-912 MHz and 918-928 MHz are available for LMS operations in accordance with section 90.105. Operations will not cause interference to government stations which operate in these bands and must tolerate interference from industrial, scientific, and medical (ISM) devices and from government stations which operate in these bands.

§90.105

* * * * *

A new Section 90.105 is added to subpart F to read as follows:

§ 90.105 Location and Monitoring Service

(a) These provisions authorize the licensing of systems in the location and monitoring service (LMS). LMS systems utilize nonvoice radio techniques to determine the location and status of vehicles and other objects. Authority is also provided for the transmission of voice and/or nonvoice messages relating to the units being located. LMS licensees authorized to operate a system in the band segments 902-912 MHz and 918-928 MHz may serve individuals, federal government agencies and entities eligible for licensing in Part 90.

(b) Frequencies for LMS operations are assignable as follows:

(1) Except for systems authorized on a developmental basis pursuant to paragraph (b)(2) of this section, LMS systems will be authorized in the 904-912 MHz and 918-926 MHz band segments. Such systems will be licensed subject to the condition that operations will not cause interference to government stations which operate in these bands and must tolerate interference from industrial, scientific, and medical (ISM) devices and from government stations which operate in these bands.

(2) LMS systems requiring bandwidth not exceeding 1 MHz may be authorized in the 903-904 MHz or 926-927 MHz band segments on a developmental basis in accordance with subpart Q and on condition that operations will not cause interference to government stations which operate in these bands and must tolerate interference from industrial, scientific, and medical (ISM) devices and from government stations which operate in these bands.

(3) No change.

(c) (d) (e)

No change.

§ 90.179

No change.

§ 90.203

No change.

§ 90.205

Section 90.205(b) is amended by adding the 902-928 MHz band to the table and by adding footnote (13) to read as follows:

(b) * * *

Frequency range (megahertz)	Maximum Output power (watts)	Maximum effective radiated power (watts)
* * * * *		
902-912 and 918-928	.....	30 ([13])
* * * * *		

13 Effective radiated power shall be measured as peak power.

* * * * *

§ 90.209

Section 90.209 is amended by adding new paragraphs (b)(10) and (m) to read as follows:

(b) * * *

(10) The maximum authorized bandwidth shall be 8 MHz for LMS operations in the band segments 904-912 and 918-926 MHz.

* * * * *

(m) No change.

§90.216

A new section 90.216 is added to subpart I to read as follows:

§90.216 Height of Antenna Structures

The maximum height above ground level at its site of an antenna structure to which is attached a transmitter authorized under Subpart F that operates in the 902-912 MHz and 918-928 MHz band segments shall be 10 meters.